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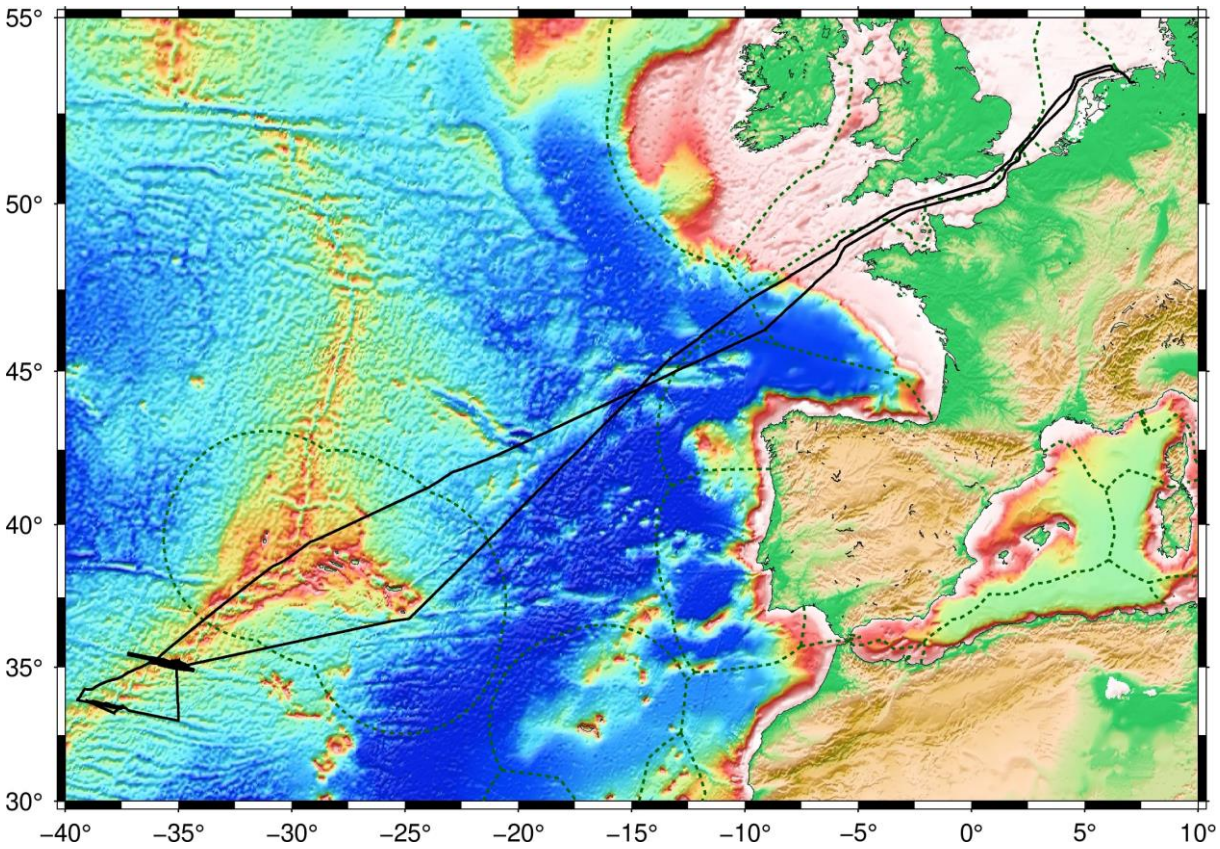
Short Cruise Report

R/V METEOR
Cruise M170 (GPF 20-3_090)

Emden, Germany – Emden, Germany
11. January – 10. February 2021
Chief Scientist: Ingo Grevemeyer
Captain: Detlef Korte



Objectives

Fracture zones were recognized to be an integral part of the seabed long before plate tectonics was established. Later, plate tectonics linked fracture zones to oceanic transform faults, suggesting that they are the inactive and hence fossil trace of transforms. Yet, scientist spend little time surveying them in much detail. Recent evidence suggests that the traditional concept of transform faults as being conservative (non-accretionary) plate boundary faults might be wrong. Instead, numerical modelling results suggest that transform faults seem to suffer from extensional tectonics below their strike-slip surface fault zone and a global compilation of legacy bathymetric data suggest that ridge-transform intersections seem to be settings of magmatic activity, modifying the lithosphere and burying the transform valley before it passes into the fracture zone region. Here we like to test both hypotheses by collecting a suite of new data from the Oceanorapher transform fault offsetting the Mid-Atlantic Ridge to the south of the Azores near 35°N and hence conducted a pilot study revealing the state-of-stress derived from micro-earthquakes and bathymetric as well as geological sampling to evaluate magmatic and tectonic processes shaping transform faults.

Narrative of the Cruise

On 11th of January 2021 METEOR left its berth in Emden at 7:30 UTC, tackling its expedition M170 to survey the Oceanographer Transform Fault, a major 120 km long ridge offset of the Mid-Atlantic Ridge to the south of the Azores.

Just 40 min after it left the cay, the vessel reached the harbour's lock; at 9:30 METEOR sailed along the river Ems and left the mouth of the Ems at noon. Strong head winds and current and waves of 3-4 m reduced the speed of the vessel, dropping below 8 kn for roughly 10 hours while heading westwards. Fortunately, conditions became better while sailing farther west and METEOR could keep a transit pace of approx. 11-12 kn for most of the time while sailing through the North Sea and English Channel, passing Dover on 12th January at ~4 p.m. and leaving the English Channel at 8 p.m. of the 13th, steaming south-westwards towards Azores at ~10-11 kn and south-westerly winds and waves of 2-3 m. On 14th of January, METEOR left the national waters of France and underway data, including swath-mapping bathymetry of the shipboard Kongsberg EM122 echosounder, were collected.

Weather prediction along the planned transit into the working area were predicted to worsen. Therefore, it was decided, based on advice of the German Meteorological Service (DWD), to choose a longer and more easterly route. However, better predicted sea conditions allowed to keep a faster transit speed of ~10 kn instead of facing strongly reduced speed and high waves to the north of Azores while passing through a fierce low-pressure

system. Additionally, the calmer sea to the east of the storm nurtured the preparation of seismic equipment on the deck of METEOR. On 15th and 16th of January, METEOR stopped three times to lower during 3 casts the release units of the ocean-bottom-seismometers to 1.000 m, testing their functionality. On Sunday 17th of January, we entered at 3:35 p.m. the territorial waters of Portugal/Azores and suspended collection of underway data.

We left the exclusive economic zone of Azores on 19th at 6 p.m. and reached the working area on 20th of January conducting a XBT station at 15:15 a.m. to collect a sound velocity profile for the swath-mapping system, converting measured travel times of the EM122 echosounder into water depth. At 17:12 p.m., OBS01 was the first ocean-bottom-station to be deployed near the eastern ridge-transform intersection. 16 hours later, the 27th OBS was deployed at the western ridge-transform intersection, providing full coverage of the Oceanographer Transform fault. Thereafter, we sailed back to the east, mapping the seafloor to the north of the transform fault before deploying two additional ocean-bottom-hydrophones on the inside corner high at the eastern RTI.

Two hours later, at ~8 p.m. UTC on 21st of January the side scan sonar was deployed in the fracture zone roughly 20 nm east of the RTI. Unfortunately, at 3.500 m water depth and hence before obtaining any data, we observed a malfunction of the system and had to recover the deep-tow system. Later, we detected that a cable was damaged. We therefore decided to run a bathymetric mapping survey along the active transform fault.

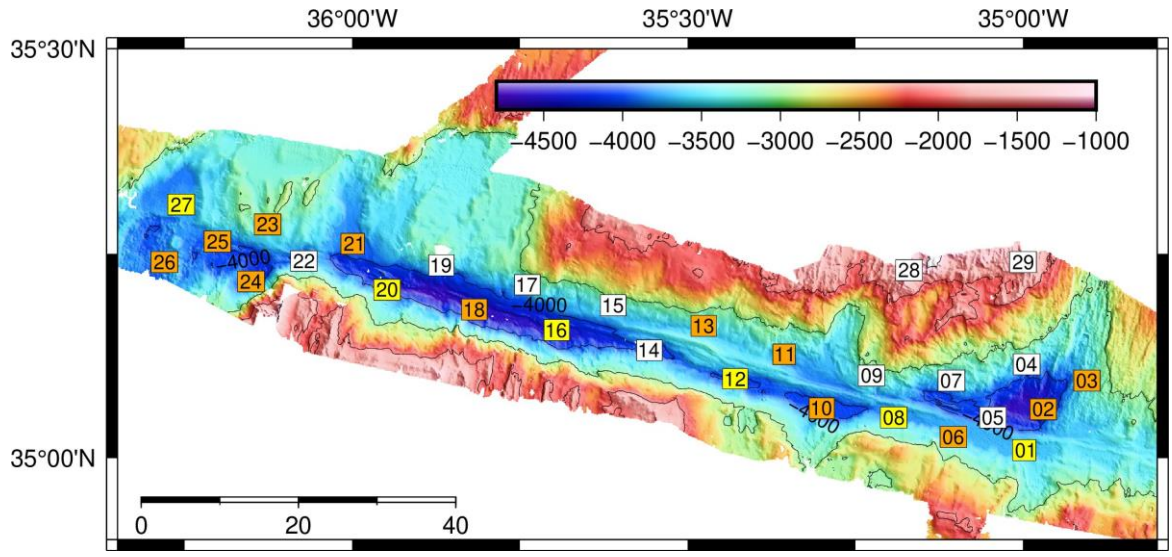


Figure 1: Deployed ocean-bottom-stations along Oceanographer transform fault.

On the 22nd of January the mapping was suspended to conduct a side scan sonar survey in the vicinity of the western RTI. Unfortunately, the communication with the side scan sonar failed immediately after it was deployed. We therefore recovered the tow-fish of the side scan sonar and steamed farther west, mapping a ~60 km long portion of the western

branch of the fracture zone. Returning to the east, we mapped the seafloor adjacent to the fracture zone and transform fault.

In the evening of the 23rd of January, we conducted the first geological station, deploying a dredge at 23 UTC on a patch of high backscatter intensity of the EM122 swath-mapping system at the toe of the southern wall of the eastern branch of the fracture zone. The dredge returned serpentinzed mantle rocks. In total, 8 additional sites were dredged in the outside corner domain of the eastern RTI and only one dredge was empty. The most common rock type was basalt.

On Monday 25th of January, we had to abandon the dredge programme as strong wind and sea with 5-6 m caused fierce rolling of the ship. Farther south conditions were predicted to be better and METEOR sailed therefore roughly 140 nm southwards. Strong headwinds and waves forced us to reduce the speed. On 27th of January, we reached the fracture zone trace of the Hayes transform fault and sailed eastward, collecting EM122 swath mapping data of good to very good quality along the Hayes transform / fracture zone system. We mapped the western fracture zone, the transform fault and the eastern fracture zone out to ~50 km from the ridge-transform intersection (RTI) on either side. Thereafter, we returned in the small hours of the 29th back to the western RTI to dredge at five different sites. Unfortunately, even in the south the weather conditions got worse and we had to cancel three of the five planned dredges. We therefore continued to map the eastern fracture zone of Hayes before sailing on the 30th of January back to the north to recover ocean-bottom-seismic stations. We reached the first OBH at 9 a.m. on 31st of January and released it. Unfortunately, weather conditions were still rough and strong wind affected the procedure. Consequently, weather conditions slowed down the recovery. Over the next 10 hours, we covered in total 6 OBH and suspended recovery during the night and conducted a short mapping campaign to close gaps in the bathymetric coverage of the Oceanographer transform fault.

In the early evening the tragic death of one of the crew members was detected; he was found dead in his cabin. Therefore, the captain decided to end the cruise as soon as possible. However, 5 OBH would release automatically on 4th of February and return to the surface. Those 5 OBH had to be recovered the next day to prevent losing the stations and data recorded during the last 10 days. Recovery began at 9 a.m. UTC and was again slowed down by bad weather. At 7 p.m. UTC of 1st of February 2021 the last of the 5 OBH was recovered and METERO left the working area, sailing back northward. Unfortunately, 18 OBS (with automatic releases programmed for summer 2022) remained on the seafloor to be recovered as soon as possible during another cruise.

During the transit towards Emden seafloor depth was mapped using the EM122 echosounder. Of course, mapping was suspended in territorial waters of Portugal/Azores and all scientific measurements were stopped on 6th of February 2021 at 11:30 UTC while entering the Spanish exclusive economic zone. We entered the English Channel in the early morning of 8th of February and reached the pilot in the mouth of the river Ems on 10th of February 2021 at 8 a.m.; four hours later, METEOR reached to lock and was back in port.

Acknowledgments

We are thankfully to Master Detlef Korte, and the crew of the RV METEOR cruise M170 for excellent sea-going support and a great working environment. The work conducted during this cruise was funded by the Deutsche Forschungsgemeinschaft (DFG) and the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany.

Cruise participants

Name	Discipline	Institution
Grevemeyer, Ingo, chief scientist	OBS	GEOMAR
Bartels, Thies, technician	OBS, side-scan	GEOMAR
Beniest, Anouk, scientist	OBS, Geology	GEOMAR
Devey, Colin W., scientist	Geology	GEOMAR
Filbrandt, Christian, student	OBS	CAU / GEOMAR
Gomez, Laura, scientist	OBS, bathymetry	GEOMAR
Hagen, Anna, student	Geology, bathymetry	CAU / GEOMAR
Hilbert, Helene-Sophie, scientist	OBS, bathymetry	GEOMAR
Klaucke, Ingo, scientist	Side scan, bathymetry	GEOMAR
Lange, Dietrich, scientist	OBS	GEOMAR
Murray-Berquist, Louisa	OBS, bathymetry	GEOMAR
Li, Yuhan, scientist	OBS, bathymetry	GEOMAR
Raeke, Andreas, technician	Metrology	DWD
Ren, Yu, scientist	OBS, bathymetry	GEOMAR
Stiller, Maike, student	OBS, bathymetry	CAU / GEOMAR
Unger, Katharina, scientist	Geology, bathymetry	GEOMAR

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CAU	Christian-Albrechts Universität zu Kiel Institut für Geowissenschaften Otto-Hahn-Platz 24108 Kiel Germany
DWD	Deutscher Wetter Dienst Bernhard-Nocht-Straße 76 20359 Hamburg Germany

Station Lists

Ocean-Bottom-Seismometer (OBS) & Hydrophone (OBH) Passive Network

Station	Latitude		Longitude		Depth in m	Type
OBS01	35° 00.57'	N	34° 59.74'	W	3698	LOBSTER
OBS02	35° 03.59'	N	34° 58.18'	W	4277	Design-02
OBS 03	35° 05.71'	N	34° 54.26'	W	3333	Design-02
OBH04	35° 06.90'	N	34° 59.63'	W	4101	OBH
OBH05	35° 03.02'	N	35° 02.66'	W	4365	OBH
OBS06	35° 01.55'	N	35° 06.23'	W	3658	Design-02
OBH07	35° 05.70'	N	35° 06.43'	W	3649	OBH
OBS08	35° 02.99'	N	35° 11.57'	W	3839	LOBSTER
OBH09	35° 06.06'	N	35° 13.56'	W	3208	OBH
OBS10	35° 03.61'	N	35° 11.03'	W	4026	Design-02
OBS11	35° 07.58'	N	35° 21.29'	W	3518	Design-02
OBS12	35° 05.80'	N	35° 25.85'	W	3944	LOBSTER
OBS13	35° 09.73'	N	35° 28.63'	W	3644	Design-02
OBH14	35° 07.92'	N	35° 33.53'	W	3952	OBH
OBH15	35° 11.21'	N	35° 36.71'	W	3334	OBH
OBS16	35° 09.43'	N	35° 41.72'	W	4441	LOBSTER
OBH17	35° 12.75'	N	35° 44.38'	W	3426	OBH
OBS18	35° 10.92'	N	35° 49.10'	W	4583	Design-02
OBH19	35° 14.16'	N	35° 52.07'	W	3544	OBH
OBS20	35° 12.36'	N	35° 56.86'	W	4068	LOBSTER
OBS21	35° 15.72'	N	35° 59.79'	W	3895	Design-02
OBH22	35° 14.47'	N	35° 04.31'	W	3751	OBH
OBS23	35° 17.14'	N	36° 07.84'	W	3057	Design-02
OBS24	35° 12.95'	N	36° 08.05'	W	4155	Design-02
OBS25	35° 15.91'	N	36° 12.05'	W	3948	Design-02
OBS26	35° 14.39'	N	36° 16.78'	W	3836	Design-02
OBS27	35° 18.57'	N	36° 15.27'	W	3793	LOBSTER
OBH28	35° 13.79'	N	35° 10.09'	W	1212	OBH
OBH29	35° 14.41'	N	35° 00.02'	W	1493	OBH

Geological Dredge Stations

Station	Latitude		Longitude		Depth in m	Result
M170_9	34°53,744'	N	34°28,771'	W	2888	successful
M170_10	34°59,021'	N	34°31,992‘	W	2806	successful
M170_11	34°57,316'	N	34°33,559'	W	3018	successful
M170_12	34°57,475'	N	34°35,469'	W	3047	successful
M170_13	34°59,050'	N	34°35,650'	W	2966	empty
M170_14	35°04,040'	N	34°44,469'	W	2144	successful
M170_15	34°53,989‘	N	34°36,745'	W	2395	successful
M170_16	34°53,823'	N	34°40,368'	W	2060	empty
M170_18	35°02,231'	N	35°02,942'	W	3813	empty
M170_19	35°03,941'	N	39°01,169'	W	3387	successful
M170_20	33°46,372'	N	39°02,788'	W	3000	successful